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Research Document 2002/091 | **Document de recherche 2002/091**

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Review of Atlantic Walrus (*Odobenus rosmarus rosmarus*) in Canada.

État des stocks de morse (*Odobenus rosmarus rosmarus*) au Canada.

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ISSN 1499-3848 (Printed)
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ABSTRACT

Four extant stocks of walrus have been identified in Canada, on the basis of genetic, isotope, body size differences, breaks in distribution or management independence, but the evidence is far from conclusive. These are, tentatively, the east and south Hudson Bay stock, the Hudson Bay-Davis strait stock, the Foxe Basin stock, and the Baffin Bay stock. However, there is also emerging information to suggest that these main groups should be further subdivided. The ranges of the Hudson Bay-Davis Strait and the Baffin Bay stocks undoubtedly extend, or extended, to Greenland and these stocks may be shared by hunters there but there are no population estimates for these two stocks, and no strong evidence of their current connectedness. Recent information suggests the Foxe Basin stock should be considered at least 2 stocks and that it may exchange animals with both northwest and northeast Hudson Bay. Serious information gaps also exist in terms of catch, catch distribution and sex and age-at-catch, natural mortality, and population responses to human disturbance.

RÉSUMÉ

Quatre stocks de morse ont été identifiés provisoirement au Canada d'après des données génétiques, des analyses isotopiques, des différences de taille, des ruptures dans la distribution ou des régimes de gestion indépendants, mais les preuves sont loin d'être concluantes. Ces stocks sont le stock de l'est et du sud de la baie d'Hudson, le stock de la baie d'Hudson et du détroit de Davis, le stock du bassin Foxe et le stock de la baie de Baffin. Mais de nouvelles données donnent à penser que ces grands groupes devraient être subdivisés. À n'en pas douter, l'aire de répartition des stocks baie d'Hudson-détroit de Davis et baie de Baffin s'étend, ou s'étendait, jusqu'au Groenland. Il se peut que les mêmes chasseurs ciblent ces deux stocks, mais aucune estimation des effectifs et aucune preuve solide d'un lien actuel entre eux n'est disponible. Les données récentes laissent supposer que le stock du bassin de Foxe devrait être considéré comme étant au moins deux stocks et que des échanges d'individus se produisent avec ceux du nord-ouest et du nord-est de la baie d'Hudson. Il existe aussi de profondes lacunes dans les données sur les captures, la distribution des captures, la répartition des captures selon le sexe et l'âge, la mortalité naturelle et les réactions des populations aux perturbations anthropiques.

Background

This summary is intended to provide background on populations of walrus (*Odobenus rosmarus)* in Canada. It draws most heavily on scientific literature but resource-user knowledge is incorporated when it is available and provides insights.

Generally, only the Atlantic walrus (*O. r. rosmarus)* is present in Canada (Reeves 1978) although there are a few extralimital records of Pacific walrus as far east as Kingaok (Bathurst Inlet) (Stewart and Burt 1996). Basic information is still lacking on the distribution, movements, and stock identity of walrus in Canada, information that is necessary to define the distribution of stocks to underpin regional allocations and sustainable yield estimates. Immediate areas of interest are Foxe Basin and the stocks adjacent to the south (Hudson Bay) and north (Baffin Bay). Internationally, it is necessary to identify and assess potentially shared stocks, such as the Baffin Bay and Hudson Bay-Davis Strait stocks.

Here **stock** is a management unit, capable of independent exploitation and management (Royce 1972). A **population** is a group of walrus with a higher probability of mating with each other than with walrus from other groups, that is, there is substantial genetic exchange within the group (Pianka 1978).

Stock Identity

The Atlantic walrus have been divided into two populations, basically one east of Greenland and one in western Greenland and Canada (Mansfield 1973, Fay 1985). There are few published data by which to further subdivide walrus groups within Canada and the naming of possible management stocks varies with the author. Most authors also do not state the basis of stock delineation - management or genetic. The Walrus International Technical and Scientific (WITS) workshop in 1990 identified three stocks in Canada (Fay *et al.* 1990): the Maritime stock; the Hudson Bay-Foxe Basin stock including Hudson Strait; and the Baffin Bay-West Greenland stock. The North Atlantic Marine Mammal Commission's (NAMMCO) *ad hoc* working group on Atlantic walrus referred to the Baffin Bay stock also as the Northwater Stock (NAMMCO 1995). The Canadian Arctic Fisheries Scientific Advisory Committee (AFSAC) identified the Canadian sub-Arctic stock of walrus to include Hudson Bay, Foxe Basin, Hudson Strait and Davis Strait (Clarke *et al.* 1989, Cosens *et al.* 1993), equivalent to the Hudson Bay-Foxe Basin stock of WITS. Both these sources appear to have used a blend of population and management stock criteria. Born *et al.* (1995) and NAMMCO (1995) separated a South and East Hudson Bay management stock and the Foxe Basin management - and possibly genetic - stock from the Hudson Bay-Foxe Basin complex. Stewart (1994) separated an eastern Baffin stock from the others but noted that all 5 stocks he identified might have further subdivisions.

For the purposes of this review, the postulated walrus management stocks in Canada are: the *Maritime* stock, *South and East Hudson Bay* stock, *Hudson Bay-Davis Strait*

stock (including Hudson Strait), *Foxe Basin* stock, and *Baffin Bay* stock. Recent unpublished data that may further subdivide these groups is presented in the discussion of each stock.

The *Maritime stock* formerly occupied the region from roughly Nova Scotia to the coast of Labrador. Its range was continuous with Hudson Strait (Richard and Campbell 1988) and the Maritime stock may have been part of the Hudson Bay-Davis Strait population. However, as a management stock, it was the subject of an intense hunt and the Committee on Endangered Wildlife in Canada (COSEWIC) designated it "extirpated" in 1987 (Richard and Campbell 1988, footnote page 337). Although there have been recent sightings of walrus in this area (Kingsley 1998), this stock is still considered extirpated and is not discussed further.

The distribution of walrus in *South and East Hudson Bay* was once continuous with western Hudson Strait (Richard and Campbell 1988) and may represent a part of this population (NAMMCO 1995). Walrus range has contracted in the northeast corner of Hudson Bay (Richard and Campbell 1988) suggesting a separation between Hudson Strait walrus and those in south and east Hudson Bay. Similarly, although there has been no noticeable decrease near Coats Island (Richard *et al. in prep.*), numbers in eastern Hudson Bay have declined, suggesting a separation of management stocks in this area. The east Hudson Bay stock appears distinct from the Foxe Basin walrus based on differences in organochlorine (Muir *et al.* 1995), concentrations of metals (Wagemann and Stewart 1994) and lead isotope ratios and element signatures (Outridge and Stewart 1999). Moreover, Akulivik and Inukjuak were distinguished by lead isotope ratios ($^{208}Pb/^{207}Pb$) indicating these two communities, only 250 km apart, take walrus from two stocks. The relationships of walrus at the mouth of James Bay and other stocks are unknown.

The *Hudson Bay-Davis Strait stock* occupies northern Hudson Bay, Hudson Strait, and Davis Strait (Fay *et al.* 1990, Richard and Campbell 1988). There are movements through Hudson Strait, east in the spring and west in the fall (Reeves 1978, Davis *et al.* 1980), but walrus also winter in western Hudson Strait (Orr and Rebizant 1987). The relationship between over-wintering animals and migrants is not known. Seasonal changes in the distribution of walrus in western Hudson Strait (Orr and Rebizant 1987) suggest local movements but it is unknown if these connect with northern Foxe Basin walrus.

Walrus that summered on Nottingham and Salisbury Islands in western Hudson Strait were thought to migrate through Ungava Bay and the eastern strait (Loughrey 1959). Walrus are present around southeast Baffin Island in the fall and some may move east to Greenland (Mansfield 1973, Born *et al.* 1995). Walrus are absent from the Sisimiut area in summer and there is no longer a fall southward migration into that area (Born *et al.* 1995) suggesting the Sisimiut animals may move west in the summer. These migrations have not been documented. Also, walrus movements within Hudson Bay are unknown and the possibility of exchange with both south and east Hudson Bay and with Greenland remains.

Walrus range, hence probably numbers, in northern Hudson Bay has shrunk in historic times (Reeves 1978) but evidence of numerical decrease since the 1950's is weak (Born *et al.* 1995). Recent surveys suggest that a decline since the 1970's is unlikely (10% probability, Richard *et al. In prep.*). Conversely the Sisimiut group on western Greenland has declined (Born *et al.* 1995) so at these extremes of the putative population, there appear to be separate management stocks. There are no data on population trends in the intervening areas where there could be several management stocks.

Walrus from northern Hudson Bay in the 1950's are smaller than those in Foxe Basin and Greenland (Garlich-Miller and Stewart 1998, Knutsen and Born 1994) but there are no recent samples from northern Hudson Bay, and none from Hudson Strait or the Canadian high Arctic.

The Hudson Bay-Davis Strait population extends past southeast Baffin Island and up Baffin's eastern coast, possibly to join the Baffin Bay population, but the evidence is not conclusive. Distribution along the east coast of Baffin Island has been identified as continuous (Loughrey 1959, Davis *et al.* 1980, Fay 1985, Richard and Campbell 1988), "scattered" (Mansfield 1973), rare (Reeves 1978), and discontinuous (Fay *et al.* 1990, Mansfield 1959). Hunters from Kangiqsugaapik (Clyde River) take a few walrus most years (DFO 1991, 1992a, 1992b, 1993 to 1997; Guinn and Stewart 1988, Richard and Campbell 1988). Evidence summarized by Reeves (1978) indicated that distribution and numbers declined between the 1930's and 1950's near and south of Kangiqsugaapik (Clyde River). In the late 1860s, walrus were abundant at Pond and Scott Inlets and Home Bay (Allen 1880 citing Brown 1868). There are no data on how continuous distribution was between these sites and today, walrus occur at the mouth of Pond Inlet, and near Kangiqsugaapik (Clyde River) with an apparent gap between the two areas (Mansfield 1967, Riewe 1992). At least part of this group was thought to winter off the northern coast of Labrador (MacLaren Atlantic 1977).

The *Foxe Basin stock* occupies the northern reaches of Foxe Basin (Mansfield 1959, 1973; Loughrey 1959, DFO 1987). Movement of walrus through Fury and Hecla Strait between Foxe Basin and the Gulf of Boothia is thought to be unlikely by scientists (Loughrey 1959, Mansfield 1959, Davis *et al.* 1981) and hunters (Garlich-Miller, pers. comm.). There is some north-south movement in Foxe Basin (Anderson and Garlich-Miller 1994), that may extend to Southampton Island (Freuchen 1935, Davis *et al.* 1980), but the autumn movement of walrus into Foxe Channel is also consistent with influx from northern Hudson Bay (Orr *et al.* 1986, Richard *et al. In prep.*). There is new evidence based on different geochemical signatures in tooth growth layers (Stewart and Outridge, unpublished) that some male walrus landed at Sanirajak (Hall Beach) have spent part of their lives in southern reaches of Foxe Basin, around Naujat (Repulse Bay) or Foxe Peninsula. No evidence of exchange was seen in walrus sampled at Iglulik. Preliminary mtDNA analysis suggests there are types of walrus in the Sanirajak catch that do not appear in Iglulik (Stewart, unpublished data). Walrus in Foxe Basin in 1990's reached greater asymptotic length than did walrus from Hudson Bay in the 1950's while males in Foxe Basin showed no change between the 1950's and 1990's (Garlich-Miller 1994, Garlich-Miller and Stewart 1998). Thus walrus at Iglulik and

Sanirajak both appear to be separate from those in northern Hudson Bay. Walrus from Sanirajak may mix with those in southern Foxe Basin while the Iglulik stock may be completely separate.

Pregnant walrus are generally not available to hunters from Hall Beach during the winter, suggesting further subdivision of this stock on based seasonal, sex, and age (Ammie Kipsigak, pers comm.).

In Canada, the *Baffin Bay stock* extends west as far as Bathurst Island, with rare reports from Prince Patrick and Melville Islands and Taloyoak (Spence Bay) on the mainland (Harington 1966). Sightings at Kinggauk (Bathurst Inlet) are thought to be extralimital Pacific walrus (Harington 1966, Stewart and Page 1995). The distribution of the Baffin Bay stock is now discontinuous with walrus in the southeast Baffin Island area although they may be related historically.

In Lancaster Sound, there is a spring movement west to Cornwallis Island and south into Prince Regent Inlet, periodically as far as the Gulf of Boothia (Read and Stephansson 1976, Davis *et al.* 1980, Riewe 1992). Routes of return fall migrations are poorly known (Read and Stephansson 1976). Hunters of Qausuittuq (Resolute Bay) suggest a concerted and brief migration east takes place in the fall and one of 10 walrus tagged at Bathurst Island in August 1993 was killed in early June 1994 in Milne Inlet, about 750 km by sea to the east (Stewart, unpublished data). Walrus from Lancaster Sound may also winter near Dundas Island. At least one walrus branded at Dundas Island was seen on the same haulout site on Bathurst Island where the walrus was tagged in 1993 (B. Sjare, pers. comm.). Whether the over-wintering animals and migrants represent different genetic stocks is unknown.

The distribution of walrus east and north from Lancaster and Jones Sounds is continuous into Greenland (Reeves 1978, Richard and Campbell 1988, Born *et al.* 1995). Walrus are thought to move regularly between the two areas (Freuchen 1921, cited by Reeves 1978) and embedded objects (bullets, harpoon heads) which are foreign have been reported (Born *et al.* 1995).

Population Size and Trend

There are no complete and modern size estimates for any walrus stock in Nunavut. For some there have been index-estimates but the confidence intervals are broad (Cosens *et al.* 1993) and only very large changes in population size could be detected. Current surveys can not be corrected for submerged animals and haulout dynamics (what portion of the population is on land or ice at the time of the survey) are unknown.

Quantitative data are used here whenever available, but the only indicators of trends in population size are often indirect: distributional changes, differences in physical condition, and harvest data. Reductions in range may indicate a smaller population. Harvest data and theoretical estimates of population growth may be used to estimate,

crudely, the direction of any population trend. Only large declines or rapid increases could be detected this way.

South and East Hudson Bay - A count of 310 was recorded in 1978 at the northeast corner of James Bay (Richard and Campbell 1988) where "over 1000" had been counted in 1955 (Reeves 1978). Estimates for the whole area are in the few hundreds (Born *et al.* 1995, Richard and Campbell 1988). The range of walrus in eastern Hudson Bay is much diminished (Reeves 1978) and hunters in northwest Quebec now hunt farther afield (Richard and Campbell 1988), suggesting a decline in population size.

Hudson Bay-Davis Strait - Richard and Campbell (1988) provided counts totalling 4000 to 5000 for this stock but noted that most population figures are guesses and trends are not detectable. There have been two aerial surveys carried out on this stock in the past 20 years. Mansfield and St. Aubin (1991) supported visual estimates made along the ice edge and at haulouts in Fisher and Evans Straits with hand-held 35 mm photography in late July - early August of 1976 and 1977. They also made photographic and visual counts on the ground at a main haulout on the east side of Coats Island. Maximum numbers recorded were 1500 in 1976 and 2400 in 1977. Similar surveys in 1988 recorded almost 1400 walrus on Coats Island and 461 on Nottingham Island a day later. While these figures can not be used to estimate stock size (Cosens *et al.* 1993), they do suggest a low probability of decline in this part of the range (Richard *et al. In prep.*). Hunters from Kingnait (Cape Dorset) reported 1000 or more walrus on southwest Baffin Island in winter and spring (Orr and Rebizant 1987).

It was thought that the distribution of walrus along the west coast of Hudson Bay was continuous from James Bay north (Loughrey 1959; Mansfield 1959; Fay *et al.* 1990) but walrus are now rare between James Bay and Tikirajuaq (Whale Cove) (Richard and Campbell 1988). In the early 1950's, walrus numbers may have been increasing south of Tikirajuaq (see Reeves 1978) but in the early 1970s residents of Arviaq (Eskimo Point) indicated (to R. Stewart) that the concentration of walrus at Marble Island near Kangiqtinq (Rankin Inlet) had not returned. Arviaq and Tikirajuaq have taken only a few walrus since the mid-1970s (DFO 1991, 1992a, 1992b, 1993 to 1997). The importance of walrus hunting declined at Kangiqtinq by the mid-1970s (Smith and Taylor 1977).

This stock is also no longer present in the upper reaches of Cumberland Sound (Allen 1880, Guinn and Stewart 1988). The distribution of walrus in Hudson Strait and Baffin Island has declined and possibly become more fragmented in historical times (Reeves 1978, Richard and Campbell 1988). If this population is continuous with the Sisimiut group in Greenland, it is reduced in that part of its range (Born *et al.* 1995).

Foxe Basin - Richard and Campbell (1988) indicated a Foxe Basin population in excess of 3700 based on a count of 2716 in the northern area (Orr *et al.* 1986) and an estimate of over 1000 for western Foxe Peninsula. Systematic, aerial surveys of walrus at the surface in northern Foxe Basin provided estimates of 5200 (95% CI = 900 to 30,500) in 1988 and 5500 (2700 to 11200) in 1989 and a low probability of decline since the 1970s (Richard *et al. In prep.*).

There has been a shift away from the west side of Foxe Basin (Brody 1976, Anderson and Garlich-Miller 1994). Many haulout sites have been abandoned (Mansfield 1966), representing a decline in population, in habitat availability, or both.

For the sub-Arctic stock of walrus, which encompassed Foxe Basin, Hudson Bay, Hudson Strait, and Davis Strait, AFSAC concluded that removals were at or above sustainable levels and the stock was probably in decline (Clarke *et al.* 1989). With newer information, AFSAC thought the probability of decline in northern Hudson Bay was small but could not assess the status of Foxe Basin walrus (Cosens *et al.* 1993). The possibility that Foxe Basin animals represent more than one stock was not realized at the time of these assessments and, indeed, animals that differ in haplotype or isotopic ratios can not be distinguished during surveys.

Baffin Bay - Over 1000 walrus are thought to summer in the Canadian high Arctic (Davis *et al.* 1978) based on surveys of known haulout sites, the ice edge, and open-water transects. A late summer survey of the coastline over 4 consecutive days in 1998 produced a total count of about 550 walrus hauled out (Stewart, unpublished data). Born *et al.* (1995) summarized counts for this area and estimated the stock size to be 1700-2000, perhaps up to 3000.

The Baffin Bay walrus stock still occupies most known areas in the central Arctic archipelago (Mansfield 1959, Loughrey 1959, Davis 1981). Walrus are now rare in the mid-reaches of the east coast of Baffin Island (Reeves 1978) and hunters at Kangiqsugaapik (Clyde River) report only small catches (DFO 1991, 1992a, 1992b, 1993 to 1997). One haulout site near Qikiqtarjuaq (Broughton Island) was abandoned after a Distant Early Warning site was constructed nearby (Reeves 1978) and at least 3 main haulout sites have been abandoned in Greenland (Born *et al.* 1995). Abandonment may be an indicator of population decline or of local disturbance.

If the Baffin Bay stock is (was) connected to the Disko Bay group in central west Greenland, it may now be much reduced in that part of its range. Large influxes to the Avanersuaq area from the south in spring no longer occur (Born *et al.* 1995).

Vital Rates

Here I assume stock-specific values apply to all stocks.

There are no estimates of natural mortality other than those implied in simulations (Working Group 3 1993).

Productivity varies among years in Pacific walrus (Sease and Fay 1987) although this variation has not been quantified for Atlantic walrus (Working Group 3 1993). Age of maturation (ovulation) in females in Foxe Basin is 5-7 years and 6-10 in Greenland (Born *et al.* 1995, Garlich-Miller and Stewart 1999) but first pregnancy may be delayed (Garlich-Miller and Stewart 1999). The reproductive interval - the time between successive calves - for these females was generally three years. The was no evidence

of ovulation in the year of parturition, 41% ovulated 1 year later but only 5% of this group of females was pregnant. The ovulation rate among females which had not given birth for 2 years was 93%, with a pregnancy rate of 57%. The overall pregnancy rate among mature females was 33% (Garlich-Miller and Stewart 1999), similar to Mansfield's (1959) estimate of 35% for northern Hudson Bay. Calving rates of 38% have been reported in Alaska (Fay 1982). Twins are uncommon, about 0.3% of observed pregnancies (Fay *et al.* 1991). Annual production was estimated to be 7% (Mansfield 1966) to 11% (Mansfield 1973). Instantaneous growth rate for Pacific walrus was estimated to be about 7%.

Estimates of sustainable yield range from 3 to 5% for a population between 59 and 93% of carrying capacity (K) (DeMaster 1984 cited in Born *et al.* 1995). The position of any Canadian stock of walrus with respect to K is unknown.

Current sustainable yields can only be calculated for Foxe Basin and the area around Coats Island in northern Hudson Bay. Lacking walrus-specific data, the estimated replacement yield of 2-5% estimated for cetaceans with similar reproduction patterns, was used. With a population indexed at 5200 to 5500, the sustainable yield in Foxe Basin would be approximately 100-275. The population estimate is incomplete and the total removal may be higher but the possibility of different stocks within Foxe Basin would require reassessment for each stock. For the segment of the Hudson Bay-Davis Strait stock which summers around Coats Island, the sustainable yield would be roughly 30-70. The proportion this group represents of the whole stock is unknown.

Recent counts of calf/adult ratios on haul-outs in the high Arctic may provide a preliminary estimate of gross annual reproductive rate. Ratios, not corrected for sex and age segregation among the haul outs suggests a calf production (measured in August) of about 10%.

The Hunt

Current Regulations

Walrus hunting is legislated under the Marine Mammal Regulations made under the Fisheries Act. These regulations specify the firearms, ammunition, and licensing conditions. An Indian or Inuk can take, without licence, 4 walrus per year unless there is a community quota (Section 26). Others may take walrus only when licensed under Marine Mammals Regulations or Aboriginal Communal Fishing Licence Regulations. Community quotas are established for Salliq (Coral Harbour) - 60, Sanikiluaq - 10, Ikpiarjuk (Arctic Bay) - 10, and Kangiqsugaapik (Clyde River) - 20. A reporting system is stipulated (17(1)) requiring hunters to maintain records of walrus taken for 2 yr.

Waste of edible parts is prohibited, as is trade in edible parts, except among Indians and Inuit (other than beneficiaries) in the Northwest Territories and Nunavut, Yukon Territories, Quebec, Newfoundland, or to beneficiaries if trade is in accordance with agreement in which beneficiary is enrolled. The regulations prohibit disturbing, killing

ineffectually, hunting without equipment to retrieve, waste of edible parts, and abandoning a killed walrus without making a reasonable effort to retrieve it. Live capture and tagging are permitted only with a licence.

All regulations in effect when the Nunavut Wildlife Management Board (NWMB) was established are deemed to have been made by NWMB, unless the final agreement stipulated otherwise. Total allowable harvests and allocations will be made by NWMB.

Walrus are not in any COSEWIC category. Export of walrus parts from Nunavut is done under DFO permit. International trade is permitted under CITES Appendix III.

Harvest levels

Arctic stocks have been used for subsistence by generations of aboriginals. In Canada, the main period of commercial harvesting started in the late 1800's and continued well into the 1900s (Reeves 1978). Commercial hunting of walrus was banned in 1928 by the Walrus Protection Regulations (Richard and Campbell 1988). Annual harvests are reported for the periods 1 April - 31 March (DFO 1991, 1992a, 1992b, 1993 to 1997), incorporating long-term or five-year averages for missing data. For this presentation, years 1992/93 to 1996/97 have been used because data for these years were most complete and had the lowest potential error (see DFO 1994). However, there were no data for Hall Beach for 2 of these 4 years and an average had top be used.

For most areas, there are no estimates of struck-and-lost rates. A loss rate of 30% was applied to the eastern Canadian Arctic in the mid-1950s, as an approximate estimate (Mansfield 1966). Smith and Taylor (1977) estimated 50-70% of walrus shot in the open water were lost in 1 hunt in which no harpoons were used. The location is not given.

South and East Hudson Bay - Harvest data are not widely available. Richard and Campbell (1988) estimated about 35 animals were taken annually from this stock. Ivujivik reported about 30/yr, about 15 of which came from Salisbury and Nottingham Islands, part of the Hudson Bay-Davis Strait range. There are no data available on loss rates. Richard (*in litt.*) reported an average harvest from Nunavik of about 80/yr, but not all these would come from the south and east Hudson Bay stock (Richard and Campbell 1988). The 5 Quebec settlements that may harvest this stock averaged 23 walrus/yr between 1986/87 and 1993/94. Sanikiluaq averaged 5/yr from 1984/85 to 1987/88 (Richard *in litt.*) but none in the 1993/94 to 1996/97 reporting years (DFO 1995 to 1997, DFO unpublished) for a total reported catch of 23 to 28. There are no estimates of losses, or wounding and orphan mortality for this stock.

Hudson Bay-Davis Strait - There are over 20 communities in Canada which may remove walrus from this stock, from Tikirajuaq (Whale Cove) on Hudson Bay, through Hudson Strait, to Kangiqsugaapik (Clyde River) on eastern Baffin Island and Killiniq in northern Quebec. The reported catch for these settlements averaged ~325/yr from 1972 to 1985 (Richard and Campbell 1988). More recent reports for the 12 NWT communities hunting this stock average about 120/yr for 1993/94 to 1996/97 (DFO 1995

to 1997, DFO unpublished), compared to about 220 for 1972-85 (Richard and Campbell 1988). The Quebec communities that are probably take from this stock average ~60, for a total reported catch of ~180/yr. There are no data on loss rates.

In central west Greenland, harvests average 60-70/year, corrected for a 30% loss rate (Born *et al.* 1995). NAMMCO (1995) used 40/yr, uncorrected for losses. Total uncorrected removals may be ~220/yr in the whole Hudson Bay-Davis Strait range.

Foxe Basin - The reported average catch from the Foxe Basin stock was 206 from 1972 to 1985 (Richard and Campbell 1988). Average harvest in 1988/89 and 1992/93 was about 200 walrus (DFO 1991, 1993). This is about half of the reported catch for the 1950's (Loughrey 1959) but is thought to be an underestimate (Anderson and Garlich-Miller 1994). Anderson and Garlich-Miller (1994) quoted hunter reports that put the number landed each year between 180 and 250, and used 215 in their economic calculations. DFO harvest statistics report catches of about 178 for 1993/94 to 1996/97 (DFO 1995 to 1997, DFO unpublished data). Although there were no data for Hall Beach in 2 of those years and averages have been used, the estimate is similar to that made by hunters (Anderson and Garlich-Miller 1994) and that range (180 to 250) is used for subsequent calculations here.

Orr *et al.* (1986) estimated a loss rate of 32% in this area during summer hunts, raising total removal to about 238-330. In Alaska, it was estimated that mortality among struck-and-lost walrus was about 55% (Fay *et al.* 1994). If this estimate applies to Foxe Basin, total hunting mortality would be about 212-294/yr. The differences between these estimates and NAMMCO's (1995) 300 reflect slight differences in the base numbers used.

AFSAC's estimated harvest for 1990/91 from the sub-Arctic stock (Foxe Basin, Hudson Bay-Davis Strait) was 339 (Cosens *et al.* 1993). This apparently used multi-year averages and, perhaps, preliminary data (DFO 1992b).

Baffin Bay Stock - Four communities (plus Creswell Bay) in this area reported average annual catches of 54 walrus between 1972 and 1985 (Richard and Campbell 1988). Reported catches between 1988/89 and 1992/93 for the years when data are available are lower, averaging 20-21/yr (DFO 1991, 1992a, 1992b, 1993 to 1997), similar to the 1993/94 - 1996/97 average of about 22 (DFO 1995 to 1997, DFO unpublished data).

Industry Perspective

There is currently no commercial exploitation of walrus in Canada, but there is increasing interest in allocating walrus to sports hunters.

Resource Status

The status of various walrus stocks in Canada is indeterminable. There are too few data for any to determine if it is increasing, decreasing or stable, or if it above or below any threshold other than some guessed pre-exploitation level. In the absence of data, we can speculate.

The Maritime stock is either extirpated or slowly recolonizing after extirpation. The east and south Hudson Bay stock, is probably reduced from former numbers and may be hunted but both Nunavut and Nunavik hunters. It appears largely isolated and is vulnerable to over exploitation. The Hudson Bay-Davis strait stock is reduced from former numbers and hunted by many communities. It is likely composed of several stocks, about which nothing is known. The Foxe Basin stock is probably reduced from numbers and sustains a fairly high level of removal. There are no obvious signs of decline but it now appears to be composed of smaller groups with varying degrees of exposure to hunting pressure. Recent surveys of haul outs in the high Arctic suggest that calf production exceeds landed harvest in Canada. Although this suggests the Baffin Bay stock may be stable or increasing, a number of unknown parameters remain: total removals in Canada; removals in Greenland (if any); finer stock structure; the presence and distribution of adult males.

Sources of Uncertainty

Evidence for the separation of most of these supposed stocks is weak or non-existent. Genetic markers have been developed (Buchanan *et al.* 1998) and genetics studies are underway (DFO, Greenland Institute of Natural Resources). DFO and the Geological Survey of Canada has developed a technique to use isotopes in the lines in walrus teeth to track the walrus through its life (Stern *et al.* 1999).

There are no recent population estimates for any stock of walrus in Canada. The estimate for Foxe Basin (5000-5500) is considered an index only (Richard *et al. In prep.*). There are about 1400 walrus around Coats and Southampton Islands in early August but the fraction of any northern Hudson Bay management stock or Hudson Bay-Davis Strait genetic stock this represents are unknown. Other estimates, counts, and changes in distribution suggest that walrus numbers have declined in most other areas since the early 1900's but these declines can not be quantified.

There are few data available on natural mortality, rates of reproduction, age of maturity, or reproductive span. Most existing data are limited in geographic and temporal scope.

Published harvest statistics are incomplete, often relying on multi-year averages to estimate the harvest. Individual reports are often associated with a wide degree of error (DFO 1991, 1992a, 1992b, 1993 to 1997). There are data on struck-and-loss rates only for a limited number of hunting situations (Orr *et al.* 1986) although losses vary with locality, season, habitat, weather, and hunter experience. There are no estimates for mortality among such struck-and-lost walrus in Canada.

Outlook

Current rates of removal are probably sustainable in the short term but there are no data on which to base long-term projections for any stock.

Management Considerations

The current management process sets harvest levels based on the number of hunters rather than the number of walrus available. This provides a gloomy outlook but the walrus Working Group of the NWMB is addressing new ways of managing walrus hunting. Options under consideration to set limits on the number of walrus killed are: (1) *status quo* which violates the Land Claims Agreement; (2) no upper limit, which would not permit sport-hunt allocations; and (3) some proportion of walrus available option.

Other considerations

Chemicals - The concentrations of lead (Pb) and mercury (Hg) were about twice as high in walrus from northern Quebec (8.0 and 0.58 g/g dry wt of liver) as from Foxe Basin, but cadmium (Cd) was higher (38 g/g) in Foxe Basin (Wagemann and Stewart 1994). Metal concentrations in walrus tissue paralleled that in clam tissue in Foxe Basin, except for Cd (Wagemann and Stewart 1994). Hg levels in walrus from Greenland were 1.78 g/g (wet wt) in liver (Born *et al.* 1981) or 0.17 g/g dry wt (Wagemann and Stewart 1994), more similar to Foxe Basin than northern Quebec. Lead isotopic ratios and concentrations in teeth of walrus sampled near Iglulik were stable from pre-industrial times to present, indicating no anthropogenic input (Outridge *et al.* 1997). The concentration of cadmium and some other metals also declined since pre-industrial times suggesting they are also at natural levels, although nickel, cobalt, copper and strontium increase significantly (Outridge *et al.* 1997). Strontium is a product of coal combustion.

Levels of DDT and PCB in walrus from Foxe Basin were similar to or lower than those reported for other Atlantic walrus (Muir *et al.* 1995). Levels from northern Quebec were significantly higher (Muir *et al.* 1995). These walrus had carbon and nitrogen ratios intermediate between ringed seal and other walrus levels, indicating they were feeding at a higher trophic level, possibly on ringed seals.

The effects of chemical contamination of walrus are unknown. Females with reproductive anomalies (Garlich-Miller and Stewart 1999) did not have unusual contaminant loads.

Disease - Walrus from Foxe Basin have tested positive for *Brucella*, indicating some previous exposure to the disease (Nielsen *et al.* 1996) but no sero-positive walrus were found in small samples from Resolute Bay, Grise Fiord or Nunavik (Nielsen *et al.* submitted, a). Although brucellosis causes reproductive disorders in other mammals,

the *Brucella* species infecting walrus has yet to be linked to disease and females with reproductive anomalies (Garlich-Miller and Stewart 1999) were not sero-positive. However, *Brucella* abortions in two bottlenose dolphins (*Tursiops truncatus*) (Miller *et al.* 1999) and a researcher in the United Kingdom developed brucellosis-type symptoms when working with pure cultures of marine mammal *Brucella* (Brew *et al.* 1999).

Fifty percent of 131 walrus tested positive for morbillivirus antibodies, indicating exposure to a virus similar or identical to phocine distemper virus (Nielsen *et al.*, submitted, b). Seropositive walrus were present in samples from Foxe Basin (60 of 114), Grise Fiord (1/5), Resolute Bay (3/4) Loks Land (1/5) but not Nottingham Island (0/3). Seropositive animals showed no signs of disease but detailed postmortems were not done.

Noise - In-air vocalizations of walrus range from as low as 13 Hz to at least 8 kHz (Miller 1985, Miller and Boness 1983). In preliminary tests, walrus ashore responded to 250 Hz and 4 kHz signals that were 10-20 dB above ambient level (Kastelein *et al.* 1993). There are no detailed data on walrus hearing or the source levels of their vocalizations (Working Group 5 1993).

The response of walrus to anthropogenic noise is varied. There is evidence of both stampedes, with the possibility of attendant mortality, and at least partial habituation to aircraft noise (Born *et al.* 1995). Similarly, some walrus may allow a ship to approach quite close and in other instances, walrus react to ships 2 km away (Born *et al.* 1995). Noise of either type has been associated with displacement from haulout sites for up to 9 h (Salter 1979). Females and calves appear to be most susceptible to disturbance by noise (Salter 1979, Miller 1982). Walrus use elaborate vocal displays during courtship (Stirling *et al.* 1987, Sjare and Stirling 1993) and tend to be vocal throughout the year (Miller and Boness 1983, Miller 1985) and there is potential anthropogenic noise to mask and interfere with basic walrus communication.

Human presence - Though nearly impossible to quantify, there is evidence that the presence of humans and human structures can disturb walrus and displace them from haulout sites. When hunted at a haulout, walrus may leave (Mansfield 1966, Smith *et al.* 1979) and eventually may abandon the site completely. Presence of a navigation aid on east Coats Island has been implicated in the displacement of walrus there.

Habitat loss - Lost habitat may be physical or biotic. In several areas in Canada, walrus have abandoned traditional haulout sites (Brody 1976, Richard and Campbell 1988). Whether this is a result of a declining population drawing away from marginal habitat or the displacement of walrus out of desirable habitat is unknown and rigorous testing of these past events is difficult. However, traditional interpretation by both resources users and scientists (Smith and Taylor 1977) tends to support the displacement hypothesis based on correlational data. Eco-tourism at haulout sites may have a similar impact in the future.

Fisheries overlapping walrus range may impact walrus populations through both physical and biotic pathways. Noise from vessels may disturb walrus, and dragging can

physically destroy the benthic community upon which walrus depend, whether the fishery is in direct competition for the prey or not (Born *et al.* 1995).

Acknowledgements

I thank S. Innes and P. Richard, FWI, and B. Stewart, Sila Consultants, for their reviews of a draft of this summary.

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